GPS navigation corrections (T11)

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The GPS Navigation Corrections tool merges the **Global Positioning Satellite** (GPS) data as recorded on the survey aircraft and the differential processed GPS data generated by the Ranger software. It applies other selected corrections and produces the final navigation data at the position of the magnetometer sensor in the aircraft. It also computes the height of the ground above (or below) the WGS84 or AGD84 datums, giving digital terrain data.

The documentation included here will describe for you the capabilities of an INTREPID GPS Navigation Corrections tool.

The tool can be adapted for real time use or used for post-processing

Customising the GPS corrections tool

If your GPS equipment is a brand other than Ranger or you require automatic transformation of data to some other datum, we can assist you to create a customised INTREPID GPS Navigation Corrections tool. This will be able to correct data from your aircraft (or ship) and differential GPS ground station, according to your practices and specifications. Please contact us for further information.

GPS navigation corrections—theory

GPS Differential corrections

The GPS data as recorded on the aircraft has built-in errors created according to US government policies. GPS differential processing software uses GPS readings from a base station to remove these errors.

GPS differential processing requires a minimum of 4 satellites. When there are less than 4 satellites available, no differential data is produced.

Post-processing option

After the flight, you can merge the inflight and base station data using the GPS differential processing software. This produces an ASCII file containing updated navigation data at a sample interval of 5 seconds.

Correcting navigation data

The inflight GPS device records navigation data typically every second. To correct all of the navigation data you need to interpolate the corrections within each 5 second interval. To obtain the corrected values, INTREPID

1. Calculates the difference between the inflight data and the differential data at each point for which they both exist (i.e., every 5 seconds),
2. Regards these differences as corrections to be applied to the inflight data,
3. Linearly interpolates the corrections for each point within the 5 second interval,
4. Applies these corrections to the inflight data, producing corrected navigation data.

Correcting for rapid variations

Rapid variations in the corrections may reduce the accuracy of the corrections. To remedy this, INTREPID also

1. Searches for abrupt steps in the original GPS data, especially the survey height field.

2 Instead of interpolating within the interval, applies the correction on one side of the step to all inflight values in the interval on that side. It then applies corrections correspondingly on the other side of the step, thus preserving the step rather than attempting to smooth it.

Where multiple steps occur it may be impossible to correlate the original GPS data with corrections. In this case INTREPID sets the intervening points in the inflight data to ***null***.

Problems associated with interpolation can lead to small steps in the final data where original steps were not detected. If this happens, INTREPID can apply a low pass filter over the final navigation data to smooth out steps or spikes.

Doppler infill corrections

The Doppler radar system on the aircraft measures and records the velocity of the aircraft. This is part of the navigation system used before GPS became available. If there are data gaps in the original navigation data or the GPS differential processed data, INTREPID can fill them using the Doppler data.

INTREPID performs the Doppler infill assuming the corrected GPS data bordering a gap are correct. It notes the Doppler data at these bordering points, then uses it as a guide for interpolating the navigation data between the points. For small gaps of the order of 5 km this is satisfactory. We recommend that for gaps approaching 10 km that you acquire the data again rather than perform the infill.

INTREPID cannot perform Doppler infill for gaps occurring at the start or end of a traverse line, since there is no correct value for calibrating the Doppler data at one end of the gap.

The Doppler system records velocity as aircraft speed in the flight path direction and across the flight path direction.

GPS time delay

There is a small delay after receiving GPS data while the GPS system calculates a position. The length of this delay is a function of the number of satellites in use. There must be a correction to compensate for this delay.

GPS time shift

Once the GPS system calculates the position, it make this data available to the aircraft acquisition system. There is usually a delay to the next fiducial at which the acquisition system can record the data. There must be a correction to compensate for this delay.

GPS receiver to magnetometer distance correction

The GPS data gives the position of the GPS receiver. The magnetometer is some distance away behind the aircraft. It is also the recording instrument most likely to have significant position errors.

For more accurate navigation data, you must adjust the GPS data to coincide with the location of the magnetometer. A typical example is the AGSO survey aircraft, where the magnetometer is 11.4 metres behind the GPS receiver. INTREPID uses this distance for the correction, known as the **magnetometer parallax** correction.

Filling GPS height data gaps using air pressure and temperature data

You can fill gaps in the GPS height data from the air pressure and temperature data recorded by the survey aircraft.

WGS84 to AGD84 conversion

GPS data relates to the WGS84 datum. Most Australian users will require their resulting dataset to relate to the AGD84 datum. Automatic transformation to this datum would be a useful feature of a GPS corrections process.

Terrain height above (or below) ellipsoid

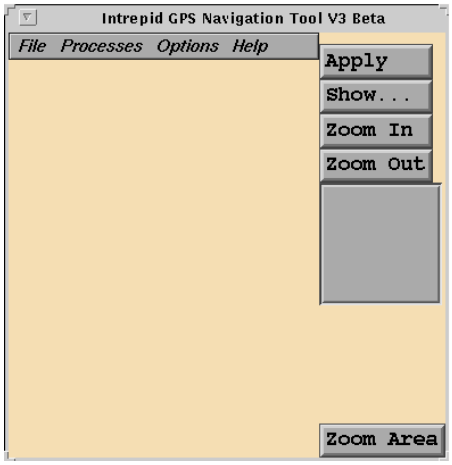
You can use the GPS height (distance to WGS84 ellipsoid) and the ground clearance to derive the terrain height (distance from the ground to the ellipsoid). If you convert the GPS height to height above some other ellipsoid, the terrain height will be relative to the other datum.

Using the GPS Navigation Corrections tool

This tool is an INTREPID module which performs the operations described above. It currently processes the data one flight at a time, so you will usually need to use it several times to process your whole survey.

>> To use GPS Navigation Corrections with the INTREPID graphic user interface:

1 Choose Navigation from the Utility menu of the Project Manager, or use the command **`gpsnav.exe`**. INTREPID displays the GPS Navigation Corrections window.



2 If you have previously prepared file specifications and parameter settings for GPS Navigation Corrections, load the corresponding task specification file using Load Options from the File menu. (See Specifying input and output files below for information about specifying files). If all of the specifications are correct in this file, go to step 7. If you wish to modify any settings, carry out the following steps as required.

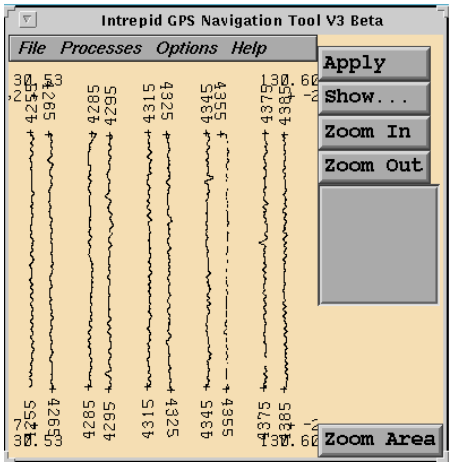
3 Specify the line dataset to be corrected and the Ranger GPS differential processing file. Use the corresponding options from the File menu. (See Specifying input and output files below for information about specifying files).

4 Specify the flight number to be processed using Flight from the Options menu. (See Specifying the flight number below).

5 Specify the corrections you wish to perform by turning on the options as required in the Processes menu (See Specifying the processes to carry out below for details).

6 Specify whether or not you wish to save the GPS differential processing corrections as a separate field file. Use Save corrections from the Options menu (See Saving the corrections below).

7 When you have specified files according to your requirements, choose Apply. INTREPID will apply the corrections to the data and display each line in the GPS Navigation Corrections window as it is processed. It plots the portions of the flight path generated by Doppler infill in red.



When the process has finished you can zoom (enlarge an area of the display) and pan (examine different regions while enlarged) (See Zooming and panning the display for details).

8 If you wish to record the specifications for this process in a task specification (**.job**) file in order to repeat a similar task later or for some other reason, use Save Options from the File menu. (See Specifying input and output files for information about specifying files).

9 If you wish to repeat the process, repeat steps 2–8, varying the specifications as required.

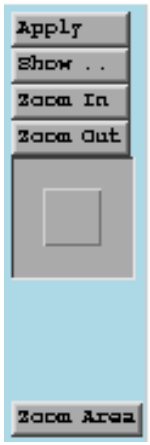
10 To exit from GPS Navigation Corrections, choose Quit from the File menu.

To view the current set of specifications choose Show from the GPS Navigation Corrections window. INTREPID displays them in a separate window. See Displaying options and using task specification files for details and an example of a set of specifications.

You can view Help information by choosing options from the Help menu (See Help).

You can execute GPS Navigation Corrections as a batch task using a task specification (**.job**) file that you have previously prepared. See Displaying options and using task specification files for details.

Zooming and panning the display



You can enlarge and reduce the display (zoom in and out) and view different parts of it (pan).

>> To zoom in and out (enlarge/reduce)

To zoom in (enlarge the display) choose Zoom In at the right edge of the GPS Navigation Corrections window. Each time you choose this button, INTREPID will enlarge the display by one step.

To zoom out (reduce the display) choose Zoom Out at the right edge of the GPS Navigation Corrections window. Each time you choose this button, INTREPID will reduce the display by one step.

>> To zoom in on a selected area of the display

Choose Zoom Area, then hold down the left mouse button and drag diagonally (corner to corner) across the area that you wish to enlarge. INTREPID will enlarge the selected region to fill the display area of the window.

>> To pan the display (view different parts)

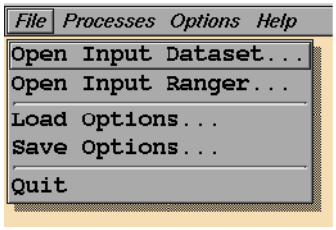
The Pan/zoom indicator at the right of the GPS Navigation Corrections window in the centre consists of a small square within a larger square. The large square represents the whole display and the small square the part visible on the screen. When you drag the small square to a different part of the large square INTREPID shows the corresponding part of the display.

If you have zoomed out to view the whole display, the small square may occupy the whole of the large square and may therefore not be visible.

Specifying input and output files

To use GPS navigation correction you must specify the line dataset to be corrected and identify the field files required for the process. You must identify the field files by giving them aliases (See "Vector dataset field aliases" in INTREPID database, file and data structures (R05) and Sample list of aliases below). This section lists the aliases required and has instructions for specifying required files.

Choose the options as required from the File menu.



In each case INTREPID displays an Open dialog box. Use the directory and file selector to locate the file you require. (See "Specifying input and output files" in Introduction to INTREPID (R02) for information about specifying files).

Vector dataset notes: INTREPID will identify fields from the dataset aliases for the process. The dataset must have the following aliases identifying appropriate fields.

Alias	Field
FlightNumber	Flight identification number.
LineNumber	Traverse line identification number.
FiducialFactor	Time in seconds that corresponds with a fiducial interval.
DateCode	Date of flight in the format DDMMYY.
MeanAltitude	Nominal height above sea level.
Bearing	Nominal bearing in degrees of traverse line measured positive east of north.
Fiducial	Fiducial data
GPStime	GPS time in 1/100 seconds since midnight on the previous Sunday.
GPSdelay	GPS delay time in 1/100 seconds.
GPStimeShift	GPS time shift in 1/100 seconds.
Clearance	Ground clearance in metres.
Temperature	The temperature data recorded by the survey aircraft.
Pressure	The air pressure data recorded by the survey aircraft.
DopplerAcross	Doppler data across the flight path in metres.
DopplerAlong	Doppler data along the flight path in metres.
X	Longitude to be corrected.
Y	Latitude to be corrected.
	INTREPID updates X and Y with the corrected values.
Terrain	Height of the ground above (or below) the datum (WGS84 or AGD84). INTREPID updates this field if you have specified that it should calculate digital terrain data.
Longcorr	Correction made to longitude
Latcorr	Correction made to latitude
	INTREPID updates the **Longcorr** and **Latcorr** fields if you have specified that the GPS corrections from the differential processing should be saved (See Saving the corrections).

See "Vector dataset field aliases" in INTREPID database, file and data structures (R05) for more information about aliases.

Open Input dataset Use this to specify the line dataset you wish to process.

Open Input Ranger Use this to specify the GPS differential processing data to be merged with the dataset that you are correcting. This is currently a text file produced by the Ranger GPS differential processing software. See GPS navigation corrections—theory for an explanation.

Load Options If you wish to use an existing task specification file to specify the GPS navigation correction process, use this menu option to specify the task specification file required. INTREPID will load the file and use its contents to set all of the parameters for the GPS navigation correction process. (See Displaying options and using task specification files for information about task specification files).

Save Options If you wish to save the current GPS navigation correction file specifications and parameter settings as a task specification file, use this menu option to specify the filename and save the file. (See Saving the corrections for more information).

Sample list of aliases

Note: These alias definitions appear in the INTREPID standard information (**.isi**) file in the following format:

```
...
X Begin
   ...
   Alias = wgs84LONG
   ...
X End
Y Begin
   ...
   Alias = wgs84LAT
   ...
Y End
...
```

Alias list:

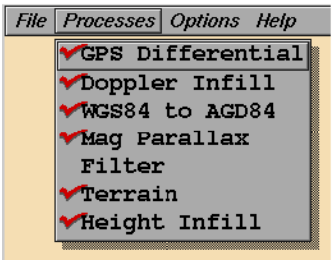
```
X = longitude
Y = latitude
Fiducial = FID
FlightNumber = /disk1/survey/TRAVERSES/flight
LineNumber = /disk1/survey/TRAVERSES/LINE
FiducialFactor = /disk1/survey/TRAVERSES/fidFactor
DateCode = /disk1/survey/TRAVERSES/dateCode
MeanAltitude = /disk1/survey/TRAVERSES/altitude
Bearing = /disk1/survey/TRAVERSES/bearing
GPStime = gpstime
GPSdelay = gpsdelay
Clearance = clearance
Temperature = /disk1/survey/TEN/temperature
Pressure = /disk1/survey/TEN/temperature
DopplerAcross = across
DopplerAlong = along
Terrain = terrain
Longcorr = longcorr
Latcorr = latcorr
```

Sample of Ranger GPS differential processing data

```
00001 ?591 931010.210035.00  -20 32 52.05477  130 20 49.11387 417.816
00002 ?591 931010.210040.00  -20 32 52.08636  130 20 49.12985 420.020
00003 ?591 931010.210045.00  -20 32 52.04481  130 20 49.21634 421.009
00004 ?591 931010.210050.00  -20 32 52.08690  130 20 49.39606 422.437
...
04096 ?591 931011.024310.00  -20 32  6.83918  130 21  4.01017 594.225
04097 ?591 931011.024315.00  -20 31 58.61532  130 20 58.40839 595.870
04098 ?591 931011.024320.00  -20 31 51.62385  130 20 51.14287 607.551
04099 ?591 931011.024325.00  -20 31 46.58258  130 20 42.24105 615.929
```

Specifying the processes to carry out

Use the Processes menu to select the correction and calculations to be performed on the dataset.



You can select any or all of the following corrections or processes. See GPS navigation corrections—theory for more detailed explanations.

To turn on the processes that you require, choose the corresponding menu options so that ticks appear against them in the menu. To turn off a process, choose its menu option again so that it has no tick against it.

GPS Differential Update the navigation data with the GPS differential processing data.

Doppler Infill Use Doppler data to fill gaps in the navigation data.

WGS84 to AGD84 Transform the navigation data from the WGS84 datum to the AGD84 datum.

Mag Parallax Adjust the navigation data to coincide with the position of the magnetometer (as opposed to the position of the GPS receiver).

Filter Smooth the navigation data using a low pass convolution filter to remove any high frequency noise.

Terrain Generate digital terrain data (height of the ground above (or below) the datum (WGS84 or AGD84, depending on the WGS84 to AGD84 setting—see above)). INTREPID combines GPS Height from the GPS differential processing data with the Ground Clearance data to derive the Terrain Height

The **Terrain** field is the only form of vertical georeference available using this tool.

Contact our technical support service for information about customising this tool for

- Automatic conversion to other datums or
- Obtaining other vertical georeference.

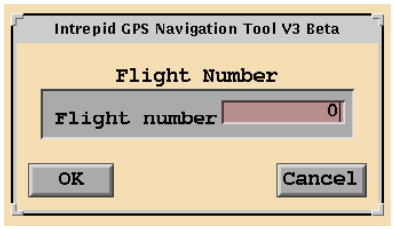
Height Infill Use pressure and temperature data to fill gaps in the GPS height data and hence the digital terrain data.

Specifying the flight number

GPS Navigation Corrections will currently process only one flight at a time. You must specify the flight number before INTREPID can carry out the process.

>> To specify the flight number of the data to be corrected, choose Flight from the options menu.

INTREPID displays the Flight number dialog box.



Specify the flight number in the dialog box and choose OK.

Saving the corrections

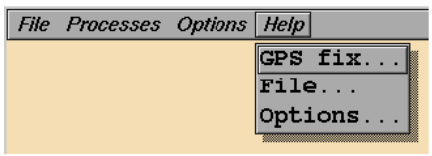
You can save the values of the GPS differential processing corrections. If you turn on the Save Corrections option in the Options menu (so that it shows a tick), INTREPID will save the corrections in the field files represented by the aliases **longcorr** and **latcorr**. To turn the option on or off, choose it from the menu.

Apply

When you choose Apply, INTREPID performs the survey distance calculation, displaying the flight paths and the report, and saving the report if required.

Help

You can use the help menu to display help text on the topics shown in the menu illustration below.



Exit

To exit from GPS Navigation Corrections choose Quit from the file menu.

Displaying options and using task specification files

Displaying options

>> To display the current task specifications

Choose Show from the GPS Navigation Corrections window. INTREPID displays the current file specifications and parameter settings in a report window.

Using task specification files

You can store sets of specifications for GPS Navigation Corrections in task specification (**.job**) files.

>> To create a task specification file with the GPS Navigation Corrections tool

1. Specify all files and parameters.
2. If possible, execute the task (choose Apply) to ensure that it will work.
3. Choose Save Options from the File menu. Specify a task specification file (INTREPID will add the extension **.job**) INTREPID will create the file with the settings current at the time of the Save Options operation.

For full instructions on creating and editing task specification files see INTREPID task specification (.job) files (R06).

>> To use a task specification file in an interactive GPS Navigation Corrections session

Load the task specification (**.job**) file (File menu, Load Options), modify any settings as required, then choose Apply.

>> To use a task specification file for a batch mode GPS Navigation Corrections task

Type the command **gpsnav.exe** with the switch -**batch** followed by the name (and path if necessary) of the task specification file.

For example, if you had a task specification file called **surv_gps.job** in the current directory you would use the command

```
gpsnav.exe -batch surv_gps.job
```

Task specification file example

Here is an example of a GPS Navigation Corrections task specification file.

```
Process Begin
   Name = gpsnav
   Parameters Begin
      DataBaseDirectory = "/disk1/surv/FL591/SEC"
      File Begin
         RangerDifferential = "disk1/surv/rng_591.asc"
      File End
      FlightNumber = 0
      DifferentialCorrectiuons = No
      DopplerInfill = Yes
      WGS84toAGD84 = Yes
      MagParallax = No
      Filter = No
      Terrain = No
      HeightInfill = No
   Parameters End
Process End
```